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Description**FIELD OF THE INVENTION**

[0001] The present invention relates to encoder-switch assemblies such as electromechanical roller-key assemblies that comprise an encoder part and two or more actuator switches. The encoder part may operate according to magnetic, optical and/or electromechanical principles and may provide one or several electrical output signals indicating the instantaneous change of angular position of a rotating roller or tuning wheel. The actuator switches provide two or more electrical output signals indicating a first or a second displaced position of the roller or wheel of the assembly.

[0002] The present encoder-switch assemblies are particularly well adapted for use in mobile phones or, generally, in any type of electronic equipment that will benefit from the very small outer dimensions and simple construction of the present encoder-switch assemblies.

BACKGROUND OF THE INVENTION

[0003] Electromechanical roller-key assemblies which may be used to generate digital control signals in response to a rotation of a roller or tuning knob and to generate an actuator switch signal in response to a depression of the roller are known from e.g. mobile phones. However, the mechanical constructions of these known devices have certain drawbacks due to a large number of miniature movable and stationary parts, often including a tiny detent spring element. This large number of separate parts requires a quite complex and labour intensive assembly procedure to assure that all parts are carefully aligned with respect to each other.

[0004] An example of an electromechanical roller-key assembly is disclosed in US 5,446,481. Here, a hybrid mouse combining the usual x and y motion signals usually found in mice together with additional degrees of freedom, particularly a z-axis signal. The z-axis signal is generated by a roller whose turning motion is sensed by a shaft angle encoder, including a light chopper. Additional degrees of freedom may be provided by tilting the roller left and right to actuate switches. Actuation of each switch, together with pulse counts from the roller may be used to indicate pitch and roll. A yaw motion signal may be provided by use of dual position detectors. In another embodiment, pitch and roll may be indicated by a trackball mounted on the mouse housing with or without the z-axis roller.

[0005] Electromechanical roller-key assemblies are often used to navigate in menus on an electric display of an apparatus. The number and the complexity of functions require that the navigation means can operate in tables and extended menu structures.

[0006] Accordingly, there is a need for an encoder-switch assembly of simplified construction with fewer parts than prior art assemblies so as to simplify the as-

sembly procedure, reduce the assembly time and, consequently, lower the costs of integrating such encoder-switch assemblies in today's mobile phones and similar compact electronic equipment. Also, there is a need for an encoder-switch assembly, which provides extended navigation possibilities.

SUMMARY OF THE INVENTION

[0007] It is an object of the invention to provide an electromechanical roller-key assembly of simple and robust construction which assembly may be integrated in electronic equipment and generate digital control signals in response to the instantaneous change in angular position of a user operated roller.

[0008] It is also an object of the invention to provide an electromechanical roller-key assembly suitable for being manufactured with very small outer dimensions, since such miniaturisation is a key requirement for applications such as hearing aids, compact mobile phones pagers, medical dispensing devices and similar handheld or body-worn devices, etc.

[0009] It is further an object of the invention to provide an electromechanical roller-key assembly comprising fewer and simpler mechanical parts compared to prior art roller-key assemblies, thereby making the present electromechanical roller-key assembly suitable for a simplified and automated factory assembly.

[0010] It is a still further object of the invention to provide an electromechanical roller-key assembly which in addition to the signals representing the rotation of the roller key provides switch signal outputs corresponding to at least four different logic states.

[0011] It is a still further object of the invention to provide methods for navigating and selecting items in tables and menus on an electronic display using a single roller key.

[0012] In a first aspect, the present invention provides a roller-key assembly, which is of a specific type comprising:

- a carrier (4),
- a roller member (2) supported by the carrier and being rotatably mounted in relation to the carrier,
- a coding member (10) engaging the roller member in a manner so as to rotate when the roller member rotates,
- the carrier being mounted in a frame (6) and being at least partly displaceable relative to the frame so as to render the roller member displaceable from an initial position to a selected displaced position of at least two predetermined displaced positions,
- means (40) for detecting rotation of the coding member in relation to the frame,

characterised in that the carrier is monolithic and that it comprises a first (4C) and a second part (4A, 4B), the first part being substantially rigidly connected to the frame, the second part being adapted to support the roller member and being displaceable relative to the first part of the carrier, the second part comprising means for generating a return spring force that returns the roller member to the initial position from the selected displaced position, the return spring force generating means forming a monolithic part of the second part of the monolithic carrier.

[0013] Optionally, the roller member is furthermore displaceable relative to the frame to a third predetermined displaced position. In this case, the roller member may furthermore be displaceable relative to the frame to a third predetermined displaced position and wherein a combination of the at least two predetermined displaced positions is in the third displaced position.

[0014] Preferably the selected displaced position is chosen by applying a predetermined force to an associated part of the roller member. The roller member may be displaceable to a first and a second predetermined displaced position,

- the first predetermined displaced position being selected by applying the predetermined force to a first end part (11) of the roller member, and
- the second predetermined displaced position being selected by applying the predetermined force to a second end part (13) of the roller member, and
- if the roller member is furthermore displaceable to a third predetermined displaced position, the third displaced position is selected by applying the predetermined force to a substantially middle part (12) of the roller member.

[0015] The carrier may be made from a plate-shaped resilient material, and the first part and the second part of the carrier may be separated by one or more indentations of the carrier to provide regions with a higher resiliency than regions of the carrier abutting the one or more indentations.

[0016] In order to transmit the rotation from the roller member to the coding member, the roller-key assembly may further comprise a shaft (36) providing a substantially rotationally rigid connection between the roller member and the coding member. The shaft is mounted so as to allow for at least parts of the roller member to be displaced in relation to the coding member along directions substantially perpendicular to the axis of rotation of the roller member. Preferably, the roller member comprises a bore wherein at least part of the shaft is positioned.

[0017] The encoder part, that is coding member and the means for detecting rotation of the coding member, may operate according to magnetic, optical and/or electromechanical principles. In order to protect the mechanical, electrical, magnetic or optic components from

contamination, the encoder part is preferably arranged inside a substantially moisture- or watertight cavity (45), parts of which is formed in the frame.

[0018] In another embodiment of the present invention, a hand-held electronic apparatus comprising the above described roller-key assembly is provided. Such hand-held electronic apparatus may be selected from the group of: mobile phones, remote controls, pagers, handheld computers, discmans, MP3-mans, GPS navigators or personal digital assistant.

[0019] The hand-held electronic apparatus may further comprise switching means (8, 9) being adapted to indicate the selected displaced position of the roller member. The switching means may comprise:

- first switching means (8) adapted to generate a first switch signal indicating that the roller member is in the first predetermined position, and
- second switching means (9) adapted to generate a second switch signal indicating that the roller member is in the second predetermined position.

[0020] The carrier or the roller member may be adapted to actuate the switching means. The switching means may comprise one or several membrane switches. The membrane switches may comprise a resilient material be adapted to provide a return spring force to the roller member when the roller member is displaced towards the switching means.

[0021] The hand-held electronic apparatus may further comprise a resilient material arranged between the switching means and the roller member so as to provide a return spring force to the roller member when the roller member is displaced towards the switching means. The resilient material may be selected from the group consisting of: rubber, plastic, foam, metal, metal alloys.

[0022] The hand-held electronic apparatus may further comprise a sealing foil (46) arranged between the switching means and the roller member so as to separate the switching means from the roller member by substantially moisture- or watertight layer. The roller member may be mounted within a substantially moisture- or watertight well (47) formed by the frame and the sealing foil, the well having an opening arranged opposite the sealing foil. The hand-held electronic apparatus may further comprise means for draining liquids and small particles from within the well, the means comprising a first opening positioned within the well.

[0023] In case of a roller-key assembly with first and second switching means, the hand-held electronic apparatus may further comprise a controller operationally connected to the switching means of the rollerkey assembly and adapted to receive the first and second switch signals. The controller is adapted to generate a first output if the first switch signal precedes the second switch signal with more than a first delay time, Δt_1 , and a second output if the second switch signal precedes the first switch signal with more than Δt_1 . Thereby the

first output from the controller indicates that the first predetermined displaced position was selected and the second output indicates that the second predetermined displaced position was selected. The output from the controller is preferably a digital output.

[0024] If the roller member is furthermore displaceable to a third predetermined displaced position, and if this third displaced position is indicated by a combination of the first and second switch signals, the controller is further adapted to generate a third output if the time interval between the first switch signal and the second switch signal is less than a second delay time, Δt_2 . Thereby, the third output indicates that the third predetermined displaced position was selected.

[0025] Preferably the value of Δt_1 equals the value of Δt_2 , and preferably the time interval Δt_1 is larger than 10 ms or 25 ms, such as larger than 50 ms or 100 ms. Accordingly, the time interval Δt_2 is preferably smaller than 100 ms or 50 ms, such as smaller than 25 ms or 10 ms.

[0026] In a second aspect, the present invention provides a method of navigating on an electronic display displaying one or more items. Such items may be tables, cells, menus, sub-menus, pop-up menus, buttons etc. The navigation takes place by moving an indicator between items; the indicator may be change of colour of the item, a cursor, a pointer, a frame around the item or any visual or acoustic feature.

[0027] The method according to the second aspect relates to moving an indicator (22) between items displayed on an electronic display, the method comprises the steps of:

- providing a roller-key assembly according to the first aspect, and
- moving the indicator between items in a first or second direction by rotating the roller member in a first or a second direction, and detecting the corresponding rotation of the coding member engaging the roller member.

[0028] The method may further comprise the step of moving the indicator between items in a third and a fourth direction by applying a predetermined force to a first or second part of the roller member so as to displace the roller member from the initial position to one of the at least two predetermined displaced positions. The method may further comprise the step of selecting an item by applying a predetermined force to a middle part of the roller member so as to displace the roller member from the initial position to a third predetermined displaced position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Hereunder, preferred embodiments of electro-mechanical roller-key assemblies according to the invention are described with reference to the drawings, wherein

Fig. 1 shows a cross-sectional view of a first embodiment of an electromechanical roller-key assembly according to the present invention,

5 Fig. 2 is an illustration of an electronic display with menus and a table,

10 Fig. 3 shows a perspective view of various elements of the first embodiment of an electromechanical roller-key assembly according to the present invention, and

15 Fig. 4 shows a perspective view of the first embodiment of the electromechanical roller-key.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0030] Figures 1 shows an electromechanical roller-key assembly according to a first preferred embodiment of the invention. A plastic moulded roller member 2 is rotatably mounted in a carrier 4, which is displaceably mounted in a supporting frame 6. In principle, the moulded roller member 2 may take any form. Preferably, the

25 centre section of the roller member (at arrow 12) has a smaller diameter than the end sections of the roller member (at arrows 11 and 13). Means for detecting the rotation of the roller member is connected to the roller member 2. A detent spring element is also mounted on the frame and returns the roller member to a relaxed position when it is vertically depressed. The mounting is so that when applying a force to the roller member at either end and perpendicular to the axis of the roller member (according to the arrows 11 or 13), the same

30 end of the roller member will be displaced leaving the opposite end of the roller member in its relaxed position. Applying a force to the centre of the roller member and perpendicular to the axis of the roller member (according to the arrow 12) will displace the entire roller member.

[0031] Two actuator contacts (8 and 9) are positioned below the roller member and depressing corresponding parts of the roller member activates either or both contacts.

[0032] It is an essential aspect of the present invention that the roller key in excess of the navigation possibilities in rolling or scrolling, provides switch signal outputs corresponding to at least four different logic states, as illustrated in Table 1 below. This is achieved by having at least two actuator contacts, which can be depressed individually or simultaneously by depressing corresponding parts of the roller member.

Table 1

Depressed	Contact 8	Contact 9
None	1	1

Table 1 (continued)

Depressed	Contact 8	Contact 9
Left end	0	1
Right end	1	0
Middle part	0	0

[0033] In order to determine the logic state of the switch signal output, it is necessary to be able to separate an output where both contacts 8 and 9 are activated, from two succeeding outputs corresponding to activation of the left contact 8 and the right contact 9 respectively. This can be solved by setting up a first time-interval Δt_1 and a second time-interval Δt_2 . If a signal from contact 8, S8, and a signal from contact 9, S9, are temporally separated by more than Δt_1 , then the signals are conceived as two individual signals from two succeeding depressions of the roller member. If however two signals S8 and S9 are temporally separated by less than Δt_2 , then the signals are conceived as a combination S8 + S9 from a single depression of the middle part of the roller member. Preferably the time-intervals Δt_1 and Δt_2 are the same. A control unit such as a microprocessor receiving the signals from contacts 8 and 9 can perform this determination, and generate digital outputs corresponding to the four logic states illustrated in Table 1.

[0034] Alternatively the same four logic states can be obtained using a combination of three contacts instead of two.

[0035] Figure 3 shows various elements of an electromechanical roller-key assembly according to the first preferred embodiment of the invention. A roller member 2 is rotatably mounted in a carrier 4. Preferably, the roller member 2 comprises a detent-bearing plug 2b and a soft rubber surface part 2a in order to provide traction for rotating the roller member with a finger. A first end surface 3 of the roller member 2 contains a corrugated groove adapted to contact a detent spring protrusion in the metal carrier 4 in order to create a tactile feedback when the roller member is rotated. A first part 4c of the carrier is rigidly mounted in a supporting structure such as the frame 6, or any casing or housing of an apparatus in which the roller key assembly is to be integrated. Actuator contacts 8 and 9 are positioned below the roller member and the frame. The contacts 8 and 9 are preferably membrane switches.

[0036] Preferably, a flexible/bendable shaft 36 transmits the rotation of the roller member 2 to a disc-shaped coding member 10. The coding member is adapted to receive the end part of the flexible/bendable shaft 36, which extends from the roller member 2 through a second part 4a of the carrier. Alternatively, the coding member engages the roller member directly, and may even be an integrated part of the roller member 2. Scanning means 40 detects the rotation of the coding member and

provides output signals characterising the rotation.

[0037] As can be seen in Figure 1, the flexible/bendable shaft 36 extends off-axis in the relaxed position of the roller member. Thereby the roller member has a longer idling when the roller member is vertically depressed. Moreover, the shaft is rotationally rigid in both the roller member 2 and the coding member 10, but is allowed to pivot in the mountings when the roller member is depressed. The coding member 36 (including shaft) and the detent-bearing plug 2b are preferably moulded in a low friction plastic resin.

[0038] The carrier 4 is preferably manufactured in a single piece of U-bend plate-shaped metal. The carrier is divided into a first part 4c rigidly mounted in the supporting frame 6 and two second parts (4a and 4b) adapted to support the roller member 2 at its end surfaces. A mechanical connection in the form of a crossbar or a shaft can be added between the two second parts 4a and 4b of the metal carrier after it has been bend into the U-shape, thereby providing a carrier of improved mechanical stability.

[0039] Utilising an insert moulding process, two plastic bearing elements 5 are attached to the second parts of the metal carrier. The plastic bearing elements are utilised to mount the roller member 2 in a precise predetermined and rotatably manner relative to the metal carrier 4. By providing two indentations in the metal carrier 4, the second parts 4a and 4b are made displaceable in relation to the first part 4c. Accordingly, when the first part 4c is rigidly mounted in a supporting structure and a force is applied to the roller member 2, one or both of the second parts is displaced from a relaxed position to a displaced position depending on the point of action of the force. When displaced, a torsion spring force is created in the carrier for returning the second part(s), and thereby the roller member, to its relaxed position, when the applied force is removed. Hence, the carrier itself functions as a detent spring so that there is no need for a separate spring element. Furthermore, the spring and displacing feature of this type of carrier is not liable to be obstructed by dirt or small particles. Another advantage of the metal carrier is that it may further act as a de-coupling element of electrostatic charge that may build up on the roller member.

[0040] Optionally, the displacement of one or both of the second parts may bring protrusions 7, which is integrated with the second parts of the metal carrier 4, in contact with one or both actuator contacts 8 or 9, arranged on e.g. a printed circuit board and positioned below the frame 6. Alternatively, the surface part of the roller member is adapted to actuate contacts 8 or 9 when depressed, e.g. by providing moulded protrusions on the roller member.

[0041] In another embodiment, the return spring force on the roller member is provided by means of a resilient material arranged below the roller member without supporting it. The resilient may be in the form of a pad, a membrane or a bulge providing a return spring force

when depressed. The material in such pad, membrane or bulge can be rubber, plastic, foam, gel, silicone, metal, metal alloys or other. In this case the carrier holding the roller member needs only to be displaceable in relation to the frame, alternatively, the roller member can be mounted directly, and displaceable, in the frame.

[0042] The coding member 36 is preferably formed by pressing a metal disc 10 with a number of holes or notches onto a number of corresponding protrusions moulded in coding member 36. The holes (or notches) and protrusions may be arranged along a substantially circular surface path. Accordingly, the coding member 36 provides an encoding disk comprising a number of intermittently arranged conducting and non-conducting pads. By providing the protrusions on the coding member 36 with substantially the same height as the thickness of the metal disc 10, a plane surface of the coding member may be provided and contacted by the at least three contact members of the scanning means 40. Thereby, during rotation of the coding member, electrical contact is intermittently established between the three contact members, and pulse trains of differing phase with respect to each other may be provided at the leg parts.

[0043] The rotation of the roller member can be detected other types of coding means than the one presented above. An optical encoder (not shown) can be realised by providing an encoder disc with variably spaced or variably sized apertures together with an LED and a photodiode. Positioning the photodiode so as to receive light from the LED through apertures in the encoder disc, the rotation speed and direction of the coding member can be determined from the pulse trains emitted by the photodiode. By using a similar scheme a magnetic encoder can be utilised.

[0044] It is desirable to protect electronic and mechanical parts from moisture and external contamination. Preferably only the roller member, the carrier and the upper rim of the frame are exposed. In the first embodiment, shown in parts in Figure 3 and assembled in Figure 4, the roller member 2 and the carrier 4 can be mounted in a substantially moisture- or watertight well 47 separating them from the other parts of the assembly.

[0045] The coding member 10 and scanning means 40 in Figure 3 are preferably arranged in a closed cavity 45 for protection against moisture, small particles and other contamination. In Figure 3, a cavity is constituted by a passage 44 formed in the frame 6 with one end closed by a lid 42. The lid 42 can be snap-fitted to the frame. Furthermore, an inner surface in the lid 42 can be provided with a projection abutting against each of the contact members of the scanning means to provide a contact or bias force between the contact members and the encoding disc.

[0046] The actuator contacts 8 and 9 are preferably protected against contamination. By abutting the lower rim of the frame 6 to a layer of sealing foil 46 of a substantially moisture- or watertight material, the well 47 is formed by the sealing foil 46, the frame 6 and the sealed

connection to the closed cavity 45. The sealing foil layer must be flexible for allowing the contacts to be actuated by the carrier or roller member. Optionally the layer is hard with resilient areas over the contacts.

5 [0047] Optionally the well 47 is connected to a drain (not shown) for draining moisture and dirt from the well. The drain can be a pipe or hose with a first opening forming a drain-hole from the well and the second end forming an outlet at the opposite side (or elsewhere) on the apparatus.

10 [0048] The output signals provided by the contacts 8 and 9 and the rotation detection means is in a preferred embodiment used to navigate between and select items in menus and tables on an electronic display 16, as shown in Figure 2. According to Figure 2, the electronic display displays three main areas, a table 17 and two menus 18 and 19, each comprising one or more items, such as a cell 20 in the table 17 or a menu option 21 in the menus 18 and 19. Each item can be assigned as active by moving an indicator 22 to the item. An active item can e.g. lead to other items as indicated by arrows 25 and 27, comprise selectable buttons 26 and 28, activate pop-up menus, or be adapted to receive inputs as for the cell 20. In Figure 2 the indicator 22 is change of colour of the item, it could also be accomplished by a cursor, a pointer, a frame around the item or any visual or acoustic feature.

15 [0049] The indicator 22 may be moved to other areas or items e.g. up or down in 17 and 18, by rotating the 20 roller member in the roller key assembly. The indicator may also be moved to other areas or items by depressing a part of the roller member corresponding to the desired direction of movement, e.g. left or right in 17 and 19. To move left, the left end part of the roller member 25 is depressed according to the arrow 11 on Figure 1; to move right, the right end part is depressed according to the arrow 13 on Figure 1. 15

20 [0050] In figure 2, some items comprise other menu options 26 and 28, such as selectable buttons. In a preferred embodiment, such items can be selected by making one of the items the active item by pressing left for 25 26 or right for 28, and thereafter select the option by pressing the middle part of the roller member. Alternatively, if there is only two options to choose between, the 30 options can be selected directly by pressing left for selecting 26 or right for selecting 28. Also, in the table 17 a cell can be selected simply by moving the indicator to the cell. Alternatively, items can be selected by voice activation or a touch pen if the indicator is already moved to the item.

35 [0051] As described in relation to Figure 2, the roller key assembly according to the present invention provides a major advantage in that the rolling and the switch signal outputs provide possibilities for two-dimensional navigation. Furthermore, the roller key assembly provides switch signals for selecting active items.

Claims**1. A roller-key assembly comprising,**

- a carrier (4),
- a roller member (2) supported by the carrier and being rotatably mounted in relation to the carrier,
- a coding member (10) engaging the roller member in a manner so as to rotate when the roller member rotates,
- the carrier being mounted in a frame (6) and being at least partly displaceable relative to the frame so as to render the roller member displaceable from an initial position to a selected displaced position of at least two predetermined displaced positions,
- means (40) for detecting rotation of the coding member in relation to the frame,

characterised in that the carrier is monolithic and that it comprises a first (4C) and a second part (4A, 4B), the first part being substantially rigidly connected to the frame, the second part being adapted to support the roller member and being displaceable relative to the first part of the carrier, the second part comprising means for generating a return spring force that returns the roller member to the initial position from the selected displaced position, the return spring force generating means forming a monolithic part of the second part of the monolithic carrier.

2. A roller-key assembly according to claim 1, wherein the roller member is furthermore displaceable relative to the frame to a third predetermined displaced position.
3. A roller-key assembly according to claim 2, wherein the roller member is furthermore displaceable relative to the frame to a third predetermined displaced position and wherein a combination of the at least two predetermined displaced positions is in the third displaced position.
4. A roller-key assembly according to any of the preceding claims, wherein the selected displaced position is chosen by applying a predetermined force to an associated part of the roller member.
5. A roller-key assembly according to claim 4, wherein the roller member is displaceable to a first and a second predetermined displaced position,

- the first predetermined displaced position being selected by applying the predetermined force to a first end part (11) of the roller member, and

- 5 - the second predetermined displaced position being selected by applying the predetermined force to a second end part (13) of the roller member.
- 10 6. A roller-key assembly according to claim 4, wherein the roller member is displaceable to a first, a second and the third displaced positions,
 - the first predetermined displaced position being selected by applying the predetermined force to a first end part (11) of the roller member,
 - the second predetermined displaced position being selected by applying the predetermined force to a second end part (13) of the roller member,
 - the third predetermined displaced position being selected by applying the predetermined force to a substantially middle part (12) of the roller member.
- 20 7. A roller-key assembly according to any of the preceding claims, wherein the carrier is made from a plate-shaped resilient material.
- 25 8. A roller-key assembly according to claim 7, wherein the first part and the second part of the carrier are separated by one or more indentations of the carrier to provide regions with a higher resiliency than regions of the carrier abutting the one or more indentations.
- 30 9. A roller-key assembly according to any of the preceding claims, further comprising a shaft (36) providing a substantially rotationally rigid connection between the roller member and the coding member, said shaft being mounted so as to allow for at least parts of the roller member to be displaced in relation to the coding member along directions substantially perpendicular to the axis of rotation of the roller member.
- 35 10. A roller-key assembly according to claim 9, wherein the roller member comprises a bore and wherein at least part of the shaft is positioned within said bore.
- 40 11. A roller-key assembly according to any of the preceding claims, wherein the frame comprises a cavity (45) housing at least the coding member and the means for detecting rotation of the coding member, said cavity being substantially moisture- or watertight
- 45
- 50
- 55

12. A hand-held electronic apparatus comprising a roller-key assembly according to any of the preceding claims.

13. A hand-held electronic apparatus comprising a roller-key assembly according to claim 3, further comprising switching means (8, 9) being adapted to indicate the selected displaced position of the roller member.

14. A hand-held electronic apparatus according to claim 13, wherein the switching means comprises:

- first switching means (8) adapted to generate a first switch signal indicating that the roller member is in the first predetermined position, and
- second switching means (9) adapted to generate a second switch signal indicating that the roller member is in the second predetermined position.

15. A hand-held electronic apparatus according to claim 14, wherein the carrier is adapted to actuate the switching means.

16. A hand-held electronic apparatus according to claim 14, wherein the roller member is adapted to actuate the switching means.

17. A hand-held electronic apparatus according to any of claims 14-16, wherein the switching means comprises one or several membrane switches.

18. A hand-held electronic apparatus according to claim 17, wherein the membrane switches comprise a resilient material and are adapted to provide a return spring force to the roller member when the roller member is displaced towards the switching means.

19. A hand-held electronic apparatus according to any of claims 14 to 18, further comprising a resilient material arranged between said switching means and the roller member so as to provide a return spring force to the roller member when the roller member is displaced towards the switching means.

20. A hand-held electronic apparatus according to claim 19, wherein said resilient material is a material selected from the group of: rubber, plastic, foam, metal, metal alloys.

21. A hand-held electronic apparatus according to any of claims 14-20, further comprising a sealing foil (46) arranged between the switching means and the roller member so as to separate the switching means from the roller member by a substantially moisture- or watertight layer.

22. A hand-held electronic apparatus according to claim 21, wherein the roller member is mounted within a substantially moisture- or watertight well (47) formed by the frame and the sealing foil, said well having an opening arranged opposite the sealing foil.

23. A hand-held electronic apparatus according to claim 22, further comprising means for draining liquids and small particles from within the well, said means comprising a first opening positioned within the well.

24. A hand-held electronic apparatus according to any of claims 14-23, wherein the hand-held apparatus is selected from a group of: mobile phones, remote controls, pagers, handheld computers, discmans, MP3-mans, GPS navigators or personal digital assistants.

25. A hand-held electronic apparatus according to any of claims 14-23, further comprising a controller operationally connected to the switching means of the roller-key assembly and adapted to receive the first and second switch signals, said controller being adapted to generate:

- a first output if the first switch signal precedes the second switch signal with more than a first delay time, Δt_1 ,
- a second output if the second switch signal precedes the first switch signal with more than Δt_1 ,

the first output indicating that the first predetermined displaced position was selected and the second output indicating that the second predetermined displaced position was selected.

26. A hand-held electronic apparatus according to claim 25, wherein the controller is further adapted to generate:

- a third output if the time interval between the first switch signal and the second switch signal is less than a second delay time, Δt_2 ,
- the third output indicating that the third predetermined displaced position was selected.

27. A hand-held electronic apparatus according to claim 26, wherein the value of Δt_1 equals the value of Δt_2 .

28. A hand-held electronic apparatus according to any of claims 25 to 27, wherein the value of Δt_1 is larger than about 10 ms.

29. A hand-held electronic apparatus according to any of claims 25 to 28, wherein the value of Δt_1 is larger than about 50 ms.

30. A method of moving an indicator (22) between items displayed on an electronic display, said method comprising the steps of

- providing a roller-key assembly according to claim 1, and
- moving the indicator between items in a first and a second direction by rotating the roller member in a first or a second direction, and detecting the corresponding rotation of the coding member engaging the roller member.

31. A method according to claim 30, further comprising the step of moving the indicator between items in a third and a fourth direction by applying a predetermined force to a first or second part of the roller member so as to displace the roller member from the initial position to one of at least two predetermined displaced positions.

32. A method according to claim 30 or 31, further comprising the step of selecting an item by applying a predetermined force to a middle part of the roller member so as to displace the roller member from the initial position to a third predetermined displaced position.

sentlichen starr verbunden ist, der zweite Teil ausgelegt ist, um das Rollenelement zu lagern und relativ zu dem ersten Teil der Halterung verstellbar ist, wobei der zweite Teil ein Mittel zum Erzeugen einer Federrückstellkraft aufweist, die das Rollenelement von der ausgewählten, verstellten Stellung in die Anfangslage zurückführt, wobei das die Federrückstellkraft erzeugende Mittel einen monolithischen Teil des zweiten Teils der monolithischen Halterung bildet.

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2. Rollentasteranordnung nach Anspruch 1, wobei das Rollenelement außerdem relativ zu dem Rahmen in eine dritte vorbestimmte, verstellte Stellung verstellbar ist.

3. Rollentasteranordnung nach Anspruch 2, wobei das Rollenelement außerdem relativ zu dem Rahmen in eine dritte vorbestimmte, verstellte Stellung verstellbar ist, und wobei eine Kombination der zu mindest zwei vorbestimmten, verstellten Stellungen in der dritten verstellten Stellung liegt.

4. Rollentasteranordnung nach einem der vorhergehenden Ansprüche, wobei die ausgewählte verstellte Stellung durch Aufbringen einer vorbestimmten Kraft auf ein zugeordnetes Teil des Rollenelements gewählt wird.

5. Rollentasteranordnung nach Anspruch 4, wobei das Rollenelement in eine erste und eine zweite

Patentansprüche

<p>1. Rollentasteranordnung, umfassend</p> <ul style="list-style-type: none"> - eine Halterung (4), - ein Rollenelement (2), das durch die Halterung gelagert wird und in Bezug auf die Halterung drehbar angeordnet ist; - ein Kodierelement (10), das sich mit dem Rollenelement in Eingriff befindet, derart, um sich zu drehen, wenn sich das Rollenelement dreht; - wobei die Halterung in einem Rahmen (6) angebracht ist und zumindest teilweise relativ zu dem Rahmen verstellbar ist, um das Rollenelement von einer Anfangslage in eine ausgewählte, verstellte Stellung von mindestens zwei vorbestimmten, verstellten Stellungen verstellbar zu machen; <p>eine Einrichtung (40) zum Erfassen einer Drehung des Kodierelements in Bezug auf den Rahmen, dadurch gekennzeichnet, dass</p> <p>die Halterung monolithisch ist und dass sie einen ersten (4C) und einen zweiten Teil (4A, 4B) aufweist, wobei der erste Teil mit dem Rahmen im We-</p>	<p>40</p> <p>45</p> <p>50</p> <p>55</p>	<p>ung verstellbar ist, der vorbestimmt wird durch Aufbringen der vorbestimmten Kraft auf ein erstes Endteil (11) des Rollenelements ausgewählt wird; und</p> <ul style="list-style-type: none"> - die zweite vorbestimmte, verstellte Stellung durch Aufbringen der vorbestimmten Kraft auf ein zweites Endteil (13) des Rollenelements ausgewählt wird. <p>6. Rollentasteranordnung nach Anspruch 4, wobei das Rollenelement in eine erste, eine zweite und die dritte verstellte Stellung verstellbar ist,</p> <ul style="list-style-type: none"> - wobei die erste vorbestimmte, verstellte Stellung durch Aufbringen der vorbestimmten Kraft auf ein erstes Endteil (11) des Rollenelements ausgewählt wird, - die zweite vorbestimmte, verstellte Stellung durch Aufbringen der vorbestimmten Kraft auf ein zweites Endteil (13) des Rollenelements ausgewählt wird, und - die dritte vorbestimmte, verstellte Stellung
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durch Aufbringen der vorbestimmten Kraft auf einen im Wesentlichen mittleren Teil (12) des Rollenelements ausgewählt wird.

7. Rollentasteranordnung nach einem der vorhergehenden Ansprüche, wobei die Halterung aus einem plattenförmigen, elastischen Material besteht.

8. Rollentasteranordnung nach Anspruch 7, wobei der erste Teil und der zweite Teil der Halterung durch eine oder mehrere Vertiefungen der Halterung getrennt sind, um Bereiche mit einer Elastizität zu bewirken, die höher ist als in Bereichen der Halterung, die an den einen oder mehreren Vertiefungen aufeinander treffen.

9. Rollentasteranordnung nach einem der vorhergehenden Ansprüche, weiter umfassend eine Welle (36), die zwischen dem Rollenelement und dem Kodierelement eine im Wesentlichen drehfeste Verbindung bewirkt, wobei die Welle so angebracht ist, damit zumindest Teile des Rollenelements in Bezug auf das Kodierelement längs der Richtungen verstellt werden können, die im Wesentlichen senkrecht zur Drehachse des Rollenelements liegen.

10. Rollentasteranordnung nach Anspruch 9, wobei das Rollenelement eine Bohrung aufweist und wobei zumindest ein Teil der Welle innerhalb der Bohrung angeordnet ist.

11. Rollentasteranordnung nach einem der vorhergehenden Ansprüche, wobei der Rahmen einen Hohlraum (45) aufweist, der zumindest das Kodierelement und die Einrichtung zum Erfassen einer Drehung des Kodierelements aufnimmt, wobei der Hohlraum im Wesentlichen feuchtigkeits- oder wassererdicht ist.

12. Handgehaltene, elektronische Vorrichtung, umfassend eine Rollentasteranordnung nach einem der vorhergehenden Ansprüche.

13. Handgehaltene, elektronische Vorrichtung mit einer Rollentasteranordnung nach Anspruch 3, weiter umfassend Schaltmittel (8, 9), die ausgelegt sind, um die ausgewählte, verstellte Stellung des Rollenelements anzuzeigen.

14. Handgehaltene, elektronische Vorrichtung nach Anspruch 13, wobei die Schaltmittel aufweisen:

- ein erstes Schaltmittel (8), das ausgelegt ist, um ein erstes Schaltignal zu erzeugen, das anzeigt, dass sich das Rollenelement in der ersten vorbestimmten Stellung befindet; und
- ein zweites Schaltmittel (9), das ausgelegt ist,

5 15. Handgehaltene, elektronische Vorrichtung nach Anspruch 14, wobei die Halterung ausgestaltet ist, um die Schaltmittel auszulösen.

10 16. Handgehaltene, elektronische Vorrichtung nach Anspruch 14, wobei das Rollenelement ausgestaltet ist, um die Schaltmittel auszulösen.

15 17. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 14 bis 16, wobei die Schaltmittel einen oder mehrere Membranschalter aufweisen.

20 18. Handgehaltene, elektronische Vorrichtung nach Anspruch 17, wobei die Membranschalter ein elastisches Material aufweisen und ausgelegt sind, um eine Federrückstellkraft auf das Rollenelement zu bewirken, wenn das Rollenelement in Richtung der Schaltmittel verstellt wird.

25 19. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 14 bis 18, weiter umfassend ein elastisches Material, das zwischen den Schaltmitteln und dem Rollenelement angeordnet ist, um auf das Rollenelement eine Federrückstellkraft zu bewirken, wenn das Rollenelement in Richtung der Schaltmittel verstellt wird.

30 20. Handgehaltene, elektronische Vorrichtung nach Anspruch 19, wobei das elastische Material ein Material ist, das aus der Gruppe von: Gummi, Kunststoff, Schaum, Metall, Metalllegierungen ausgewählt ist.

35 21. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 14 bis 20, weiter umfassend eine Dichtungsfolie (46), die zwischen den Schaltmitteln und dem Rollenelement angeordnet ist, um die Schaltmittel durch eine im Wesentlichen feuchtigkeits- oder wassererdichte Schicht von dem Rollenelement zu trennen.

40 22. Handgehaltene, elektronische Vorrichtung nach Anspruch 21, wobei das Rollenelement in einem im Wesentlichen feuchtigkeits- oder wassererdichten Schacht (47), der durch den Rahmen und die Dichtungsfolie gebildet wird, angebracht ist, wobei der Schacht eine Öffnung aufweist, die der Dichtungsfolie gegenüber liegend angeordnet ist.

45 23. Handgehaltene, elektronische Vorrichtung nach Anspruch 22, weiter umfassend eine Einrichtung zum Ablassen von Flüssigkeiten und kleinen Teilchen aus dem Inneren des Schachtes, wobei die

Einrichtung eine erste Öffnung aufweist, die innerhalb des Schachtes angeordnet ist.

24. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 14 bis 23, wobei die handgehaltene Vorrichtung aus der Gruppe von: Mobiltelefonen, Fernbedienungen, Funkrufempfängern, handgehaltenen Computern, CD-Abspielgeräten, MP3-Abspielgeräten, Satellitennavigatoren oder PDA-Computern ausgewählt ist. **5**

25. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 14 bis 23, weiter umfassend einen Regler, der mit den Schaltmitteln der Rollentasteranordnung funktionsfähig verbunden und ausgelegt ist, um das erste und das zweite Schaltignal zu empfangen, wobei der Regler ausgelegt ist, um:

- ein erstes Ausgangssignal zu erzeugen, wenn das erste Schaltignal dem zweiten Schaltignal mit mehr als einer ersten Verzögerungszeit Δt_1 vorausgeht; **20**
- ein zweites Ausgangssignal zu erzeugen, wenn das zweite Schaltignal dem ersten Schaltignal mit mehr als Δt_1 vorausgeht;

wobei das erste Ausgangssignal anzeigt, dass die erste vorbestimmte, verstellte Stellung ausgewählt wurde, und das zweite Ausgangssignal anzeigt, dass die zweite vorbestimmte, verstellte Stellung ausgewählt wurde. **25**

26. Handgehaltene, elektronische Vorrichtung nach Anspruch 25, wobei der Regler weiter ausgelegt ist, um:

- ein drittes Ausgangssignal zu erzeugen, wenn der Zeitabstand zwischen dem ersten Schaltignal und dem zweiten Schaltignal geringer als eine zweite Verzögerungszeit Δt_2 ist, **40**
- wobei das dritte Ausgangssignal anzeigt, dass die dritte vorbestimmte, verstellte Stellung ausgewählt wurde.

27. Handgehaltene, elektronische Vorrichtung nach Anspruch 26, wobei der Wert von Δt_1 dem Wert von Δt_2 entspricht. **50**

28. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 25 bis 27, wobei der Wert von Δt_1 größer als etwa 10 ms ist. **55**

29. Handgehaltene, elektronische Vorrichtung nach einem der Ansprüche 25 bis 28, wobei der Wert von Δt_1 größer als etwa 50 ms ist.

30. Verfahren zum Bewegen einer Anzeigeeinrichtung (22) zwischen Datenelementen, die auf einem elektronischen Display abgebildet werden, wobei das Verfahren die Schritte umfasst:

- Bereitstellen einer Rollentasteranordnung nach Anspruch 1;
- und Bewegen der Anzeigeeinrichtung zwischen Datenelementen in eine erste und eine zweite Richtung durch Drehung des Rollenelements in eine erste oder eine zweite Richtung, und Erfassen der entsprechenden Drehung des mit dem Rollenelement in Eingriff befindlichen Kodierelements. **15**

31. Verfahren nach Anspruch 30, weiter umfassend den Schritt des Bewegens der Anzeigeeinrichtung zwischen Datenelementen in eine dritte und eine vierte Richtung durch Aufbringen einer vorbestimmten Kraft auf einen ersten oder zweiten Teil des Rollenelements, um das Rollenelement von der Anfangslage in eine der mindestens zwei vorbestimmten, verstellten Stellungen zu verstellen. **20**

32. Verfahren nach Anspruch 30 oder 31, weiter umfassend den Schritt des Auswählens eines Datenelements durch Aufbringen einer vorbestimmten Kraft auf einen mittleren Teil des Rollenelements, um das Rollenelement von der Anfangslage in eine dritte vorbestimmte, verstellte Stellung zu verstellen. **25**

Revendications

1. Assemblage de touche à roulette comprenant,

- un support (4),
- un élément roulette (2) soutenu par le support et étant monté en rotation par rapport au support,
- un élément codeur (10) en prise avec l'élément roulette d'une manière telle à tourner lorsque l'élément roulette tourne,
- le support étant monté dans un cadre (6) et étant au moins partiellement déplaçable par rapport au cadre, de façon à rendre l'élément roulette déplaçable d'une position initiale jusqu'à une position déplacée choisie parmi au moins deux positions déplacées prédéterminées,
- un moyen (40) pour détecter la rotation de l'élément codeur par rapport au cadre,

caractérisé en ce que le support est monolithique et en ce qu'il comprend une première (4C) et une seconde (4A, 4B) partie, la première partie étant sensiblement reliée, de façon rigide au cadre,

la seconde partie étant adaptée à soutenir l'élément roulette et étant déplaçable par rapport à la première partie du support, la seconde partie comprenant un moyen pour produire une force de ressort de rappel qui ramène l'élément roulette dans la position initiale par rapport à la position déplacée choisie, le moyen générateur de force de ressort de rappel constituant une partie monolithique de la seconde partie du support monolithique.

2. Assemblage de touche à roulette selon la revendication 1, dans lequel l'élément roulette est, de plus, déplaçable par rapport au cadre jusqu'à une troisième position déplacée prédéterminée.

3. Assemblage de touche à roulette selon la revendication 2, dans lequel l'élément roulette est, de plus, déplaçable par rapport au cadre jusqu'à une troisième position déplacée prédéterminée et dans lequel une combinaison des au moins deux positions déplacées prédéterminées est la troisième position déplacée.

4. Assemblage de touche à roulette selon l'une quelconque des revendications précédentes, dans lequel la position déplacée choisie est choisie en appliquant une force prédéterminée à une partie associée de l'élément roulette.

5. Assemblage de touche à roulette selon la revendication 4, dans lequel l'élément roulette est déplaçable dans une première et une deuxième position déplacée prédéterminée,

- la première position déplacée prédéterminée étant choisie en appliquant la force prédéterminée à une première partie d'extrémité (11) de l'élément roulette, et
- la deuxième position déplacée prédéterminée étant choisie en appliquant la force prédéterminée à une seconde partie d'extrémité (13) de l'élément roulette.

6. Assemblage de touche à roulette selon la revendication 4, dans lequel l'élément roulette est déplaçable dans une première, une seconde et la troisième position déplacée,

- la première position déplacée prédéterminée étant choisie en appliquant la force prédéterminée à une première partie d'extrémité (11) de l'élément roulette,
- la deuxième position déplacée prédéterminée étant choisie en appliquant la force prédéterminée à une seconde partie d'extrémité (13) de l'élément roulette, et
- la troisième position déplacée prédéterminée étant choisie en appliquant la force prédétermi-

née à une partie sensiblement médiane (12) de l'élément roulette.

7. Assemblage de touche à roulette selon l'une quelconque des revendications précédentes, dans lequel le support est fait d'une matière élastique en forme de plaque.

8. Assemblage de touche à roulette selon la revendication 7, dans lequel la première partie et la seconde partie du support sont séparées d'un ou plusieurs décalages du support pour constituer des régions avec une élasticité plus grande que les régions du support en butée avec le ou les décalages.

9. Assemblage de touche à roulette selon l'une quelconque des revendications précédentes, comprenant, en outre, un arbre (36) constituant une liaison rigide sensiblement en rotation entre l'élément roulette et l'élément de codage, ledit arbre étant monté de manière à permettre au moins à des parties de l'élément roulette d'être déplacées par rapport à l'élément codeur dans des directions sensiblement perpendiculaires à l'axe de rotation de l'élément roulette.

10. Assemblage de Louche à roulette selon la revendication 9, dans lequel l'élément roulette comprend un alésage et dans lequel au moins une partie de l'arbre est positionnée à l'intérieur dudit alésage.

11. Assemblage de touche à roulette selon l'une quelconque des revendications précédentes, dans lequel le cadre comprend une cavité (45) logeant au moins l'élément codeur et le moyen de détection de la rotation de l'élément codeur, ladite cavité étant sensiblement étanche à l'humidité ou à l'eau.

12. Dispositif électronique portatif comprenant un assemblage de touche à roulette selon l'une quelconque des revendications précédentes.

13. Dispositif électronique portatif comprenant un assemblage de touche à roulette selon la revendication 3, comprenant, en outre, un moyen de commutation (8, 9) adapté à indiquer la position déplacée choisie de l'élément roulette.

14. Dispositif électronique portatif selon la revendication 13, dans lequel le moyen de commutation comprend :

- un premier moyen de commutation (8) adapté à produire un premier signal de commutation indiquant que l'élément roulette est dans la première position prédéterminée, et
- un second moyen de commutation (9) adapté à produire un second signal de commutation in-

diquant que l'élément roulette est dans la seconde position prédéterminée.

15. Dispositif électronique portatif selon la revendication 14, dans lequel le support est adapté à actionner le moyen de commutation.

16. Dispositif électronique portatif selon la revendication 14, dans lequel l'élément roulette est adapté à actionner le moyen de commutation.

17. Dispositif électronique portatif selon l'une quelconque des revendications 14 à 16, dans lequel le moyen de commutation comprend un ou plusieurs commutateurs à membrane.

18. Dispositif électronique portatif selon la revendication 17, dans lequel les commutateurs à membrane comprennent une matière élastique et sont adaptés à fournir une force de ressort de rappel à l'élément roulette lorsque l'élément roulette est déplacé vers le moyen de commutation.

19. Dispositif électronique portatif selon l'une quelconque des revendications 14 à 18, comprenant, en outre, une matière élastique agencée entre ledit moyen de commutation et l'élément roulette, de façon à fournir une force de ressort de rappel à l'élément roulette lorsque l'élément roulette est déplacé vers le moyen de commutation.

20. Dispositif électronique portatif selon la revendication 19, dans lequel ladite matière élastique est un matériau choisi dans le groupe constitué de : caoutchouc, matière plastique, mousse, métal, alliages métalliques.

21. Dispositif électronique portatif selon l'une quelconque des revendications 14 à 20, comprenant, en outre, une feuille d'étanchéité (46) agencée entre le moyen de commutation et l'élément roulette, de façon à séparer le moyen de commutation de l'élément roulette par une couche sensiblement étanche à l'humidité ou à l'eau.

22. Dispositif électronique portatif selon la revendication 21, dans lequel l'élément roulette est monté dans un puits sensiblement étanche à l'humidité ou à l'eau (47) formé par le cadre et la feuille d'étanchéité, ledit puits ayant une ouverture agencée à l'opposé de la feuille d'étanchéité.

23. Dispositif électronique portatif selon la revendication 22, comprenant, en outre, un moyen pour évacuer les liquides et les petites particules de l'intérieur du puits, ledit moyen comprenant une première ouverture positionnée à l'intérieur du puits.

24. Dispositif électronique portatif selon l'une quelconque des revendications 14 à 23, dans lequel le dispositif portatif est choisi dans le groupe constitué des : téléphones portables, télécommandes, dispositifs de recherche de personnes, ordinateurs portatifs, baladeurs, baladeurs MP-3, navigateur GPS ou assistants numériques personnels.

25. Dispositif électronique portatif selon l'une quelconque des revendications 14 à 23, comprenant, en outre, un contrôleur relié fonctionnellement au moyen de commutation de l'assemblage de touche à roulette et adapté à recevoir les premier et second signaux de commutation, ledit contrôleur étant adapté à produire :

- une première sortie, si le premier signal de commutation précède le second signal de commutation de plus d'un premier temps de retard, Δt_1 ,
- une deuxième sortie, si le second signal de commutation précède le premier signal de commutation de plus de Δt_1 ,

26. Dispositif électronique portatif selon la revendication 25, dans lequel le contrôleur est adapté, en outre, à produire :

- une troisième sortie si l'intervalle de temps entre le premier signal de commutation et le second signal de commutation est inférieur à un second temps de retard, Δt_2 ,
- la troisième sortie indiquant que la troisième position déplacée prédéterminée a été choisie.

27. Dispositif électronique portatif selon la revendication 26, dans lequel la valeur de Δt_1 est égale à la valeur de Δt_2 .

28. Dispositif électronique portatif selon l'une quelconque des revendications 25 à 27, dans lequel la valeur de Δt_1 est supérieure à environ 10 ms.

29. Dispositif électronique portatif selon l'une quelconque des revendications 25 à 28, dans lequel la valeur de Δt_1 est supérieure à environ 50 ms.

30. Procédé de déplacement d'un indicateur (22) entre des éléments affichés sur un dispositif d'affichage électronique, ledit procédé comprenant les étapes consistant à

- fournir un assemblage de touche à roulette se-

ion la revendication 1, et

- déplacer l'indicateur entre des éléments dans une première et une deuxième direction en faisant tourner l'élément roulette dans une première ou une deuxième direction et détecter la rotation correspondante de l'élément de codage en prise avec l'élément roulette.

31. Procédé selon la revendication 30, comprenant, en outre, l'étape consistant à déplacer l'indicateur entre les éléments dans une troisième et une quatrième direction en appliquant une force prédéterminée à une première ou une seconde partie de l'élément roulette, de façon à déplacer l'élément roulette de la position initiale jusqu'à l'une des au moins deux positions déplacées prédéterminées. 10

32. Procédé selon la revendication 30 ou 31, comprenant, en outre, l'étape consistant à choisir un élément en appliquant une force prédéterminée à une partie médiane de l'élément roulette, de façon à déplacer l'élément roulette de la position initiale jusqu'à une troisième position déplacée prédéterminée. 20

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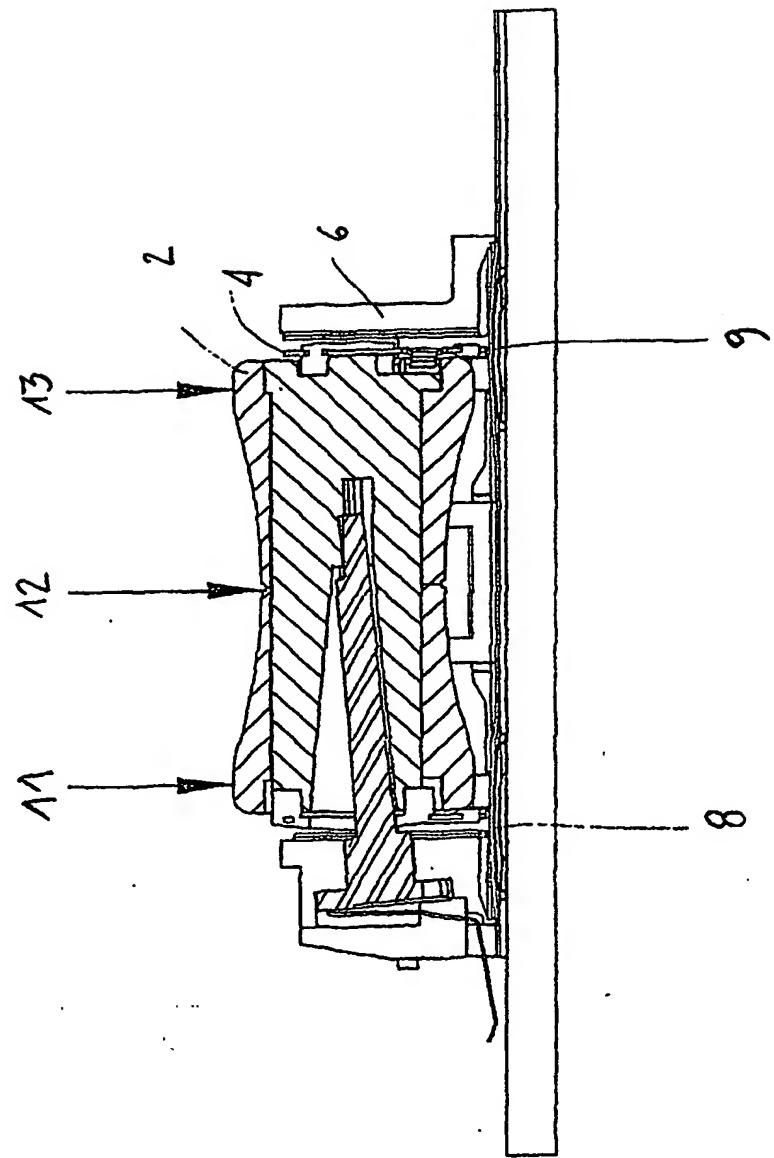


Fig. 1

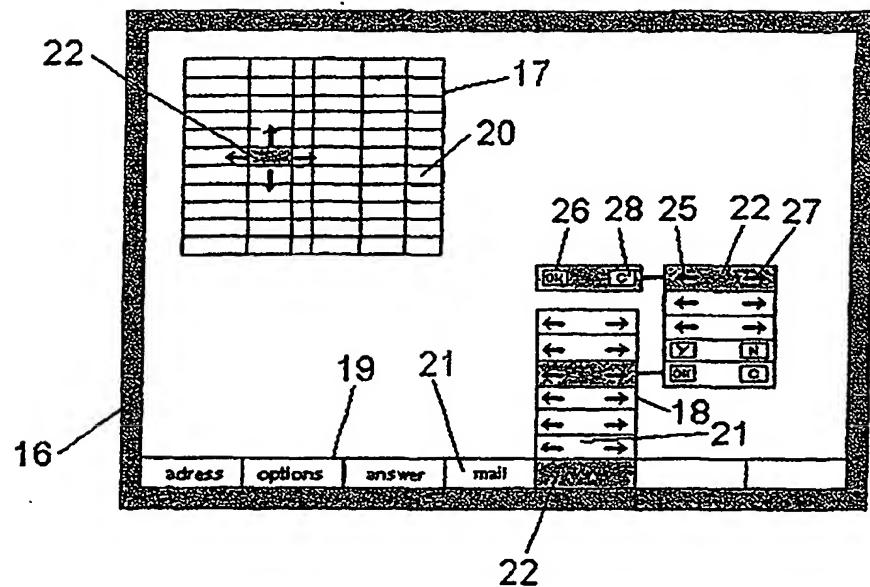


Fig. 2

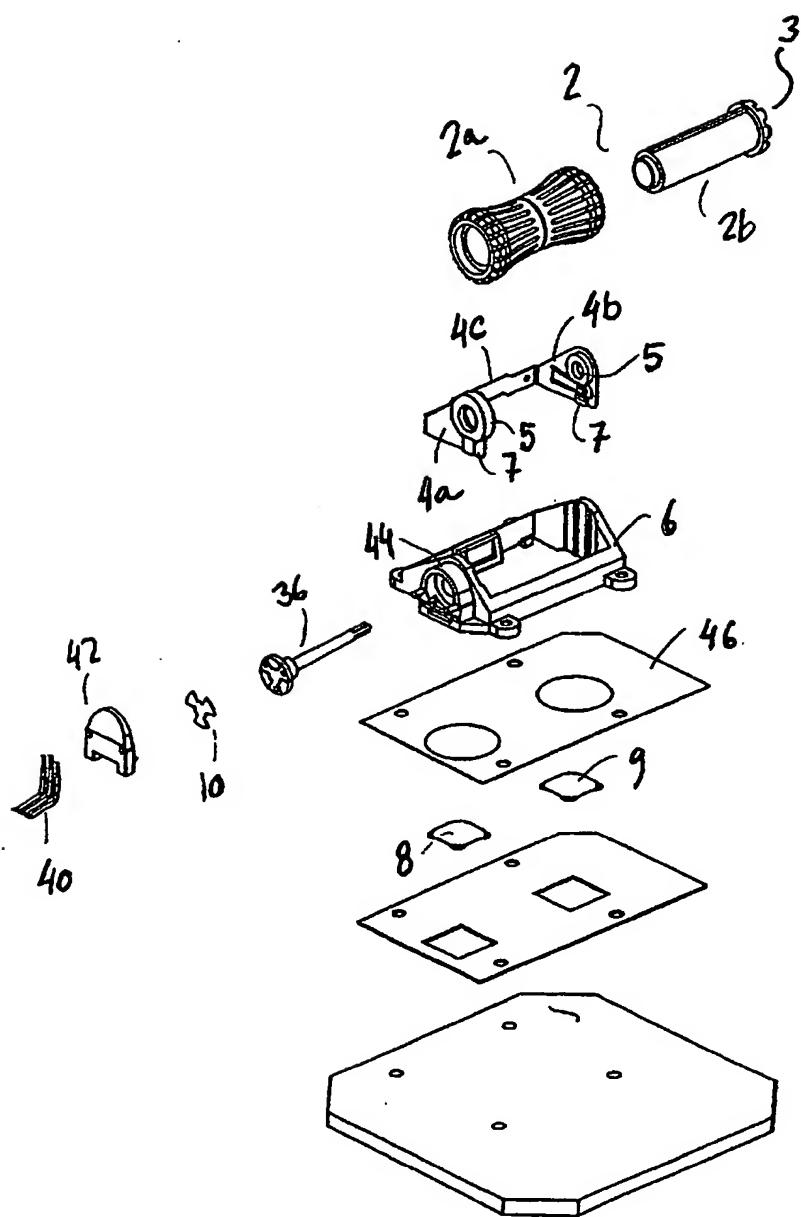


Fig. 3

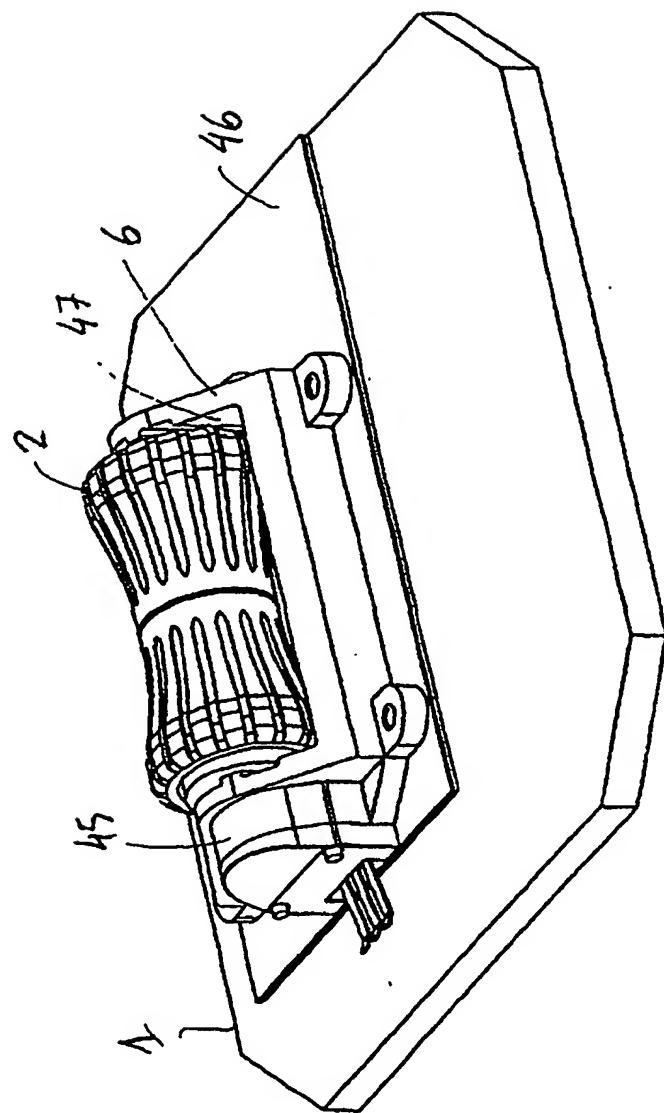


Fig. 4